# Bicilavadora
# The Pedal-Powered Washing Machine
# IDEAS 2005 Proposal

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## Project Summary

In the developing world, washing laundry is a difficult, time-consuming task that falls solely on women. Mothers and daughters typically spend 8 hours each week scrubbing each piece of their family's clothing and wringing out the harsh washing solution by hand.

Powered washing machines exist, but they are impractical in rural regions because running water and electric are expensive or unavailable. Several groups already tried to build machines for these regions but they have been unsuccessful. Their machines were either expensive to build and repair because they require imported parts or they do not wash effectively.

Our invention is the *Bicilavadora*, a low cost, pedal-powered washing machine that is designed around readily available parts. Its innovation is its simple design and its use of inexpensive plastic barrels and bicycle components. The Bicilavadora is reliable, easy to operate and uses no electricity. The parts are available locally, so Bicilavadoras can be manufactured and repaired in the community without depending on imported goods.

Our community partner is MayaPedal, a non-governmental organization in Chimaltenango, Guatemala, that currently builds and sells pedal-powered machines in their community. People in Chimaltenango have already asked MayaPedal to develop a washing machine, so the demand is clear. MayaPedal is eager to work with us to develop the Bicilavadora and their community has already proven that they will accept novel pedal-powered technology. After the Bicilavadora gains acceptance in Chimaltenango, we will share the technology with people around the world with the same need.

# 1 Background

## 1.1 Need

In developing countries, rural women are among the least privileged. Women are both essential to the family unit and integral to the economy, yet they rarely have equal opportunities for education, career development, or social status when compared to men.

One factor behind the inequality is the long list of responsibilities that traditionally fall to women. Not only do women perform agricultural duties and care for livestock alongside men, but women are also responsible for many domestic chores. Usually, new technology improves people's efficiency, but women benefit less from new technology for several reasons. First, women's duties are neglected by technological improvement efforts because domestic chores are often seen as cultural obligations for women so little effort is expended to diminish them. Second, foreign aid in the form of appropriate technologies is unevenly distributed because women are often considered less technically competent than men. Factors like these tend to prevent the development of improved technology for women's uncompensated, time-consuming, and laborious tasks.

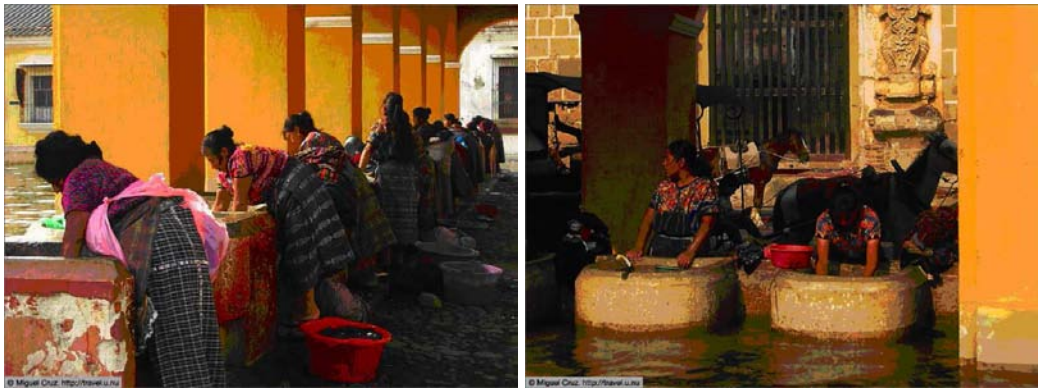

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Figure 1: Women washing laundry in Guatemala. Currently, women wash and wring out each clothing item individually by hand. They must bend over the tanks and submerge their hands in washing solution for 8 hours each week.

Our team intends to directly address the plight faced by women by developing a pedal-powered washing machine. Our target community for a proof-of-concept design is Chimaltenango, Guatemala. We have found a strong local partner in a non-governmental organization called MayaPedal who currently produces and sells pedal-powered machines, or bicimáquinas. They produce pedal-powered grain grinders, blenders, and cement-tile shakers from unusable bicycle parts donated by partner organizations in the US, such as Bikes-not-Bombs. MayaPedal has been successful at introducing these pedal-powered technologies to men and women in nearby rural communities as laborsaving devices and as means of generating income.

The success of MayaPedal's bicimáquinas is proof that pedal power is effective and applicable to their community. Women's cooperatives that use MayaPedal's blender to make and sell fruit drinks or aloe shampoos in the market have actually requested a pedal-powered washing machine that would allow them to spend more time on profitable tasks and less time doing chores. An

average woman may do two to three loads per week for a family of about five children and her husband. It generally takes at least 8 hours of washing time, not including the extra time needed to walk to the public washing reservoir or hang up clothes to dry. Additionally, while washing clothes by hand, women spend hours leaning over a concrete basin. Clothes are washed by laboriously scrubbing each section of cloth over a cement washboard with their hands immersed in detergents that are harmful to the skin.

A pedal-powered washing machine would allow women to wash clothes faster and with less strain. When asked what they would do with their free time, women said that they would try to generate income by making crafts or food to sell. Young daughters who help their mothers with domestic chores may also have the opportunity to concentrate more on their studies. Laundromat micro-enterprises may even arise if our washing machines are successful. Conditions vary in developing countries, but women in many regions are washing clothes manually while they could be doing more profitable or rewarding work elsewhere.

Several local organizations across Central America and Africa have already expressed an interest in pedal-powered technology. It is an affordable, environmentally-friendly alternative to devices powered by electricity or fossil fuels. Since it is based on bicycle components, the machines can be manufactured locally and repair parts are affordable and readily available. We are hoping that the Bicilavadora, designed to be produced and maintained in any culture where bicycle technology exists, will help to bring appropriate technology and opportunities to women in developing nations across the world and pave the way for other pedal-powered or appropriate technologies that would help women.

## 1.2 Prior Art

There are existing solutions to the clothes washing problem, but no existing technology is both practical and affordable for people in our target community. Existing solutions are either designed for industrialized nations with running water and electricity, or they are not practical for rural setting where replacement parts are difficult to find.

Commercial washing machines have existed for many years, but they are expensive and require electricity to operate. Sometimes, they are available in urban settings, but the average family cannot afford to purchase one. In rural areas, commercial washing machines are not an option because electricity may be unavailable or extremely expensive.

A number of groups [1] have modified commercial washing machines to power them with human power. They attached a pedal-drive mechanism to the washing machine drum and attached a suspension system. This technique is not feasible in rural areas of developing nations because washing machines and their old components are usually difficult to find.

Commercial hand-cranked washing machines do exist, but they are not intended for continuous use; they are designed for traveling or camping trips. The "Wonderwash" produced by *T*he Laundry Alternative, Inc. only washes 5lb of clothes and is not designed to hold up to the rigors of constant use. Priced at about US $50 in the US, it is likely to arrive in rural areas at a much higher

[1] Example: Campus Center for Appropriate Technology at Humboldt State University - `http://www.humboldt.edu/~ccat/pedalpower/`

price, and its use will be limited by the lack of replacement parts.

In the past, MayaPedal attempted to make a pedal-powered washing machine from locally available materials, but it was unsuccessful. They built a prototype with a vertical axis agitator(See Figure 2), but it did not wash clothes well, it did not have spin dry capability and it consumed a great deal of water. Although MayaPedal recognizes the demand for pedal-powered washing machine, it does not have the resources or time to design, prototyping and refine a new device.

Images removed due to copyright restrictions.
Please see: http://www.mayapedal.org/fotos/galeria/grandes/lavadora.jpg

Figure 2: MayaPedal's prototype washing machine shows that demand exists, but it is difficult to use and it damages clothing.

# 2 Innovation

Clothes washing is very specific to particular cultures, but most cultures perform the task in the same way. In almost all underdeveloped rural areas, women wash clothes by hand, using cold or lukewarm water that they carry from a river or pull up from a well.

Existing technologies for washing clothes do not work well in underdeveloped rural areas. Lack of electricity make powered machines unusable. Difficult transportation due to poor road conditions or just geographical distances create problems with imported devices that might need replacement parts or maintenance repairs.

Our Bicilavadora is novel because it solves the clothes washing problem in an efficient, affordable and practical way. To our knowledge, no one has successfully built a washing machine with these goals in mind.

## 2.1 Mechanical Design

Our design resembles a commercially available horizontal axis washer. The inner drum which holds the clothes is currently constructed by modifying a plastic utility tub. Tubs like these are widely available in Guatemala, but could easily be substituted for other types of buckets, perforated sheet metal or mesh, depending on availability. The inner drum is perforated, so that spinning the drum will extract water from the garments. There are also three triangular fins inside the inner drum that agitate the clothes during the wash cycle.

The main structure of the machine consists of a simple tube frame. The frame can be built by modifying an existing bicycle frame. The inner drum is mounted on one side of a pedal shaft. Rotational force turns the drum via a drive gear attached to the opposite side of the pedal shaft. A bicycle chain connects the gear at the drum to a set of pedals mounted on the Bicilavadora frame. The pedals are mounted close to the ground so that the operator can pedal the machine while seated in a regular chair.

There is an outer barrel that surrounds the inner drum and contains all the water. In our current design, the outer barrel is constructed using a common plastic oil drum. The operator loads and unloads clothing from the inner drum through a cutout on the side of the outer barrel. The operator drains the soapy water and rinse water by opening a drain value at the bottom of the barrel.

A convenient feature of the Bicilavadora is the optional table mounted above the structure. The operator can use her hands to do manual work like weaving while pedaling the machine. Women in Chimaltenango expressed interest in this particular feature.

## 2.2 Ease of Use

Our Bicilavadora will be easy to use by younger and older women. After loading the machine, washing requires three cycles. Between each cycle, the drum spins quickly to draw the water out of the clothing, as it drains out of the drum. In the first cycle, water and detergent are added to the drum. The operator pedals the machine for roughly 25 minutes, spins, and drains the water. The next two cycles are rinse cycles. In each rinse cycle, the operator pours clean water into the machine, pedals for 10 minutes, spins, drains the drum. After the last rinse cycle, the operator spins the clothes dry and saves the slightly soapy water for the next wash cycle.

Our research into existing washers and our earlier prototypes indicate that the power required for washing and spinning is relatively low. We demonstrated that it is not difficult to spin a perforated plastic drum up to extraction speeds with clothes inside. For these experiments, we used a geared transmission from a bicycle.

Both younger and older women can generate enough power for the wash and spin cycles. We estimate this power to be 50-75 watts. While familiarity with pedaling in general and the machine in particular will reduce the effort expended by the user, no prior experience will be necessary for its operation. The ability to change gearing ratios will allow some level of tuning to individual users and also allow for shorter wash times with more power input or conversely less strenuous operation if the user can pedal for a longer amount of time.

## 2.3 Justification

- **Efficient**: It is much more efficient to wash clothes using the Bicilavadora than to use the manual washing tanks. The Bicilavadora washes and dries many clothes concurrently whereas each item must be washed individually in the wash tank.

  The Bicilavadora also requires less energy when compared to vertical axis washing machines. The horizontal axis of rotation in the Bicilavadora uses less power because it rotates

continuously without changing directions. The operator does not need to combat the momentum and drag forces of a barrel full of water.

The Bicilavadora is also more comfortable to use than the washing tanks. The operator does not need to lean over the washing tank and submerge her hands in the soapy water. Instead, the operator sits on the Bicilavadora's seat and pedals most of the time. She only needs get up to load the machine, change the water and unload the machine. This leaves her hands free to work on making crafts and keeps them out of the harmful detergent.

- **Affordable**: The target buyer for our Bicilavadora is an entire community in contrast to a single family. A natural location to install a Bicilavadora is at the public washing stations. The women already use the washing stations and they will be able to share the washing machine among the entire community(See Figure 1. With a common washing machine, an individual family will not need spend a large sum of money for a home washing machine. Those who would not normally be able to afford such a device would be able to use one for free or for a small fee.

  A Bicilavadora is also inexpensive to operate because the user does not need to pay for power. This is especially important in places like Chimaltenango, where electricity is extremely expensive.

  MayaPedal receives its bicycle parts as donations, we have minimized the use of other materials like angle iron and wood to reduce the cost to the end customer.

- **Easy to Build and Maintain**: Unlike any of the other alternatives, the Bicilavadora uses locally available materials or recycled bicycle parts. It can be produced in any area that has prevalent bicycle technology and things like plastic buckets. Since the parts are widely available, the Bicilavadora can serve as a basis for local entrepreneurs to start micro-enterprises which would stimulate the local economy.

  Another advantage of using locally available parts is that the Bicilavadora is easy to repair. It is mechanically simple enough that any bicycle repair shop would be able to service the pedal-drive.

# 3 Implementation

## 3.1 Work to date

Our team has been developing a prototype Bicilavadora for proof of concept in the MIT D-Lab class. Currently, we have a mock up prototype with a inner drum, outer drum and pedaling mechanism. We have also visited the Chimaltenango location and interviewed local people about their interest in a Bicilavadora.

## 3.2 Implementation Plan & Timeline

Going forward, we must complete our first prototype of the Bicilavadora and work out the technical challenges. After we have a working prototype, we intend to travel to Chimaltenango and build a prototype with the locally available parts. With this second prototype, we will run a small trial period with one of the local women's groups. We will collect their feedback and revise our design. We will then run a larger scale trial period and place a Bicilavadora at the public washing station. Depending on the feedback from this trial period, we may need to revise the design again.

To transfer the technology to MayaPedal, we will write a production manual that contains fabrication techniques and an operating manual. MayaPedal will be able to continue constructing Bicilavadora for their home community after we depart. For a detailed account of our timeline, see Table 1.

If our work with MayaPedal is successful, we will try to distribute the Bicilavadora pedal powered technology to other places in Central America and Africa where other groups have expressed a strong interest in pedal-power technology. To ensure that these sites have the infrastructure to produce bicimáquinas, we will implement the training program and distribute the production manuals through Bikes Not Bombs, a Boston-based organization that donates used bicycles to developing nations.

| Date | Stage Completed |
|---|---|
| | *Initial Prototype* |
| 5-27-05 | Complete First Prototype |
| 6-03-05 | Write documentation for first prototype |
| | *First Trial* |
| 6-09-05 | Depart for Guatemala |
| 6-17-05 | Build second prototype using local parts |
| 6-20-05 | Install prototype in women's cooperative |
| 7-01-05 | Get feedback during first trial |
| 7-04-05 | Find incompatibilities |
| 7-04-05 | Revise Design |
| | *Second Trial* |
| 7-08-05 | Build three new prototypes |
| 7-08-05 | Hire an instructor from first trial to demonstrate washer at washing station |
| 7-10-05 | Install prototype in public washing station |
| 7-12-05 | Install prototypes in more cooperatives |
| 7-29-05 | Get feedback during second trial |
| 8-01-05 | Revise Design |
| | *Technology Transfer* |
| 8-05-05 | Write a fabrication manual |
| 8-07-05 | Write a user manual |
| 8-11-05 | Teach a technician to build the Bicilavadora |

Table 1: Time table for Bicilavadora trials. Dates are deadlines.

## 3.3 Challenges

One of the main challenges we face in introducing the pedal-powered washing machine is cost. The machine must be inexpensive and easy to build if it will be adopted into the community. We recognized this need and designed the machine from the start with low cost in mind. The machine will only contain parts that are readily available in Guatemala. This eliminates the need to order or import components just for the washing machine. The machine also uses bicycle parts for all the precision parts. These parts are very inexpensive because MayaPedal has a surplus of unused bicycle parts.

Another challenge we may face is acceptance into the community. The pedal-powered washing machine is quite different from the community's current method of washing clothes; the community may be reluctant to try the new machine. To help encourage the adoption of the washing machine, we will run multiple trials with local women so we can adjust the design to meet their needs. We will run the trial periods with groups like the women's cooperative who are already familiar with pedal powered machines; they have already proved they are willing to try new technologies. If women in the cooperative accept and use the machines, then they will serve as spokes-people for the new machine in their local community. Their support will greatly increase the credibility of the machine so that local people will be willing to try it.

## 3.4 Support Network

- **Mario Juarez** is the administrator, spokes-person and financial manager of MayaPedal.
- **Carlos** is the single technician and engineer at MayaPedal. He has designed and built most of the MayaPedal machines.
- **Carl Kurz** is helping us spread pedal-powered technology. He is the founder of Bikes Not Bombs and he is a partner in the Maya Pedal organization. He has experience setting up bicycle distribution sites in developing nations.
- **Allen Armstrong** is our team's advisor from the MIT D-lab class. He is an MIT alumnus who designed bicycle brakes that work well in wet weather conditions. He also has experience with recumbent bicycles.
- **Kurt Kornbluth** has taught our team about small scale manufacturing and training for third-world workers. He has 10 years of experience setting up wheelchair shops all over Africa and Central America with Whirlwind Wheelchairs. He designed the jig for the Whirlwind wheelchair.
- **Gwyndaf Jones** is helping our team with small scale manufacturing. He is experienced in the Toyota production model, and cofounded Merlin Metalworks, a commercial bicycle manufacturing company.
- **David Gordon Wilson** is a human power expert and the author of *Bicycle Science*, the authoritative guide and comprehensive reference for anything having to do with bicycles. He is the official advisor to the MIT student MayaPedal team.

| **Item** | **Estimated cost** |
|---|---|
| Flight Expenses | $600 |
| Housing (1 person, 2 months) | $380 |
| Food | $300 |
| | |
| Prototyping Materials | |
| – one pre-summer prototype | $250 |
| – 4-5 prototypes locally | $1000 |
| | |
| Equipment | |
| – welder | $500 |
| – welding supplies (gas, wire, electricity) | $400 |
| – hand tools | $300 |
| | |
| Electricity | $100 |
| | |
| Training Local Manufacturer (2 weeks) | $140 |
| Local publicity materials | $300 |
| Local instruction packages | $200 |
| Compensating Local Trainer / Publicizer (10 days) | $50 |
| | |
| Post-Summer Documentation | $300 |
| **Total Cost** | **$ 4820** |

Table 2: Predicted Budget

# 4 Budget

The support of an IDEAS award will make it possible for our team to finish developing the Bicilavadora and to perform trial runs to refine its design. It is unrealistic to believe we can design an appropriate washing machine without input and testing from our target community. With an IDEAS award, we will be able to travel to Chimaltenango and perform realistic user studies so that we can refine the Bicilavadora and maximize its ultimate impact. An IDEAS award will also enable our team to fully document our design and allow us to share it with other communities outside of Guatemala. See Table 2 for a detailed budget.

# 5 Community Connection & Impact

Our community partner is MayaPedal, a non-governmental organization in Chimaltenango, Guatemala. MayaPedal has been working with their local people for several years, building and selling pedal powered machines. The community is accepting of pedal-powered machines and the machines have become extremely popular.

MayaPedal has established partnerships with several community organizations, including women's

support groups. During our March trip to Guatemala, we visited one of these groups, namely Mujeres en Accion. The Mujeres currently use pedal-powered machines in their group and are willing to try new pedal-powered machines. During our visit, we asked the Mujeres if they would be able to use a mechanical washing machine. They were very excited and supportive because they normally spend 10 hours washing each load of clothing. They assured us that any time they could save doing laundry would be used for other productive tasks. Women's groups like the Mujeres will be important for the success of our project because they will give us constructive feedback and help to introduce the Bicilavadora to other women in the community.

MayaPedal also has strong ties to their customers, many of whom are extremely supportive of pedal-power technology and open to new ideas. We will use their social network to help us introduce the Bicilavadora to the community. For example, the executive supervisor at MayaPedal introduced us to the mayor of Chimaltenango during our trip. He was extremely interested in our work, and promised to help us in any way that he could. He will be a valuable resource, especially since he can help us to advertise the washer machine through local newspapers and radio stations.

The target population for the Bicilavadora will be the women in the community. They spend several hours each day washing clothes. The work is difficult and requires them to immerse their hands in harsh chemicals for long periods of time. The washing machine will be designed so that they must only load the clothes, water and soap then pedal. Contact with chemicals will be limited. The washer machine will be more efficient than hand washing so that the task will require less energy and also allow the women to maintain a more comfortable position. The extra time that they save will allow them to spend more time attending to their other responsibilities. Many of the women also work in small tiendas or sell their home made goods at markets. Extra time may allow them to earn more money to support themselves, or give them free time to improve themselves.

Although we are first introducing the Bicilavadora to Chimaltenango, the technology is useful in other regions as well. We will distribute the Bicilavadora technology to other places in Central America and Africa where people have expressed a strong interest in pedal-power technology. To ensure that these sites have the infrastructure to produce bicimáquinas, we will implement the training program and distribute the production manuals through Bikes Not Bombs, a Boston-based organization that donates used bicycles to developing nations.

We expect that other groups will benefit from our work with pedal-power. While we are in Guatemala, we plan to work closely with the machinist at MayaPedal to help him improve his techniques and overall manufacturing methods. In order to accommodate the additional Bicilavadora machine, we will either have to teach MayaPedal's machinist how to make the new product or train another person to weld. If we teach the current machinist, then we will also be able to improve his welding techniques and help him to work faster and more efficiently. If we train another person, then MayaPedal will benefit by having another trained machinist.

# 6 Team Members

- Teresa Baker is a first year grad student in Mechanical Engineering. She worked on the Kinkajou as part of the MIT course Product Design (2.009). She is interested in energy efficiency and sustainability. Her thesis project includes building apparatus to freeze ice cream with reduced energy consumption. Through seminars in appropriate technology at MIT and volunteering at CASPAR and Bikes-Not-Bombs, she has been exposed to the varied needs of communities and ways to interact effectively.

- Stephanie Dalquist is a second year master's student in Technology and Policy with a background in chemical engineering (SB '02) and materials science (M.Eng '03). Her graduate thesis is on opportunities for technical development in the interior of Brazil, and she worked for the MIT Lab for Manufacturing and Productivity studying conventional manufacturing techniques like machining and casting. She speaks Spanish like a Castilian, and spent a summer studying at the University of Havana.

- Kimberly Harrison is a sophomore in Mechanical Engineering (class of '07). She is also interested in electrical engineering, programming and biology. She is fairly proficient in basic Spanish. Through workshops in the Edgerton Center, Pappalardo and LMP machine shop, she has become well acquainted with common machine shop tools. She has had a wide-range of technical experiences through various internships in engineering firms and laboratories: materials testing, AutoCAD and SolidWorks, energy efficiency, and product design and manufacture.

- Radu Raduta is a senior in Aeronautics and Astronautics who is deeply interested in appropriate technologies, especially local fabrication. He has mechanical engineering design experience, and some experience with small-scale manufacturing and bicycle mechanics. He is currently enrolled in the D-Lab class developing a pedal-powered washing machine to be manufactured at MayaPedal, and currently learning Spanish.

- Jessica Vechakul is an undergraduate senior in Mechanical Engineering, who is passionately pursuing further education and a career in sustainable international development and appropriate technologies. She is now part of the team working on designing and building the first pedal-powered washing machine prototype. Her primary contribution to Bicilavadora would be engineering skills in design, machining, CAD, brazing, and welding. She knows basic Spanish from four years of study in high school, and is studying independently to improve her engineering vocabulary and verbal communication.

- Alexander Yip is a third year Ph.D. student in EECS. He has had a passion for sustainable development and bicycles for many years. He has years of practical experience with bicycles, including everything from minor repairs to brazing bicycles frames together starting with tubes. He is an alumnus of the Design that Matters seminar where he worked on a hand-operated peanut shelling machine. He earned his S.B. from MIT in 2001, and his M.Eng from MIT in 2002 and has basic Spanish skills.